



Armed Forces College of Medicine AFCM



Carbohydrates & protein digestion

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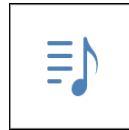
INTENDED LEARNING OBJECTIVES (ILO)



By the end of this lecture the student will be able to:

1- Outline phases of carbohydrate & protein digestion

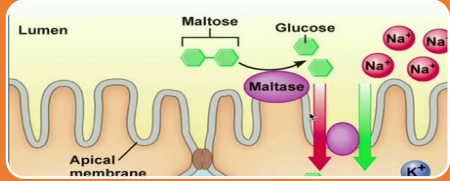
2. Categorize different digestive enzyme needed for carbohydrate & protein digestion



3. Summarize absorption of amino acids

4. Correlate clinical disorders to enzyme deficiencies.

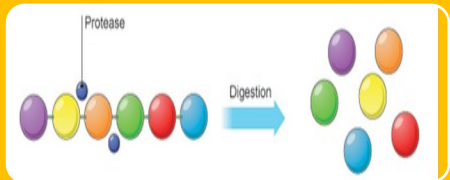
Content



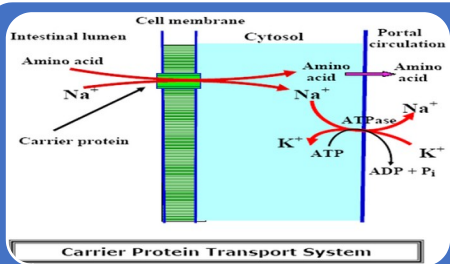
Carbohydrates digestion



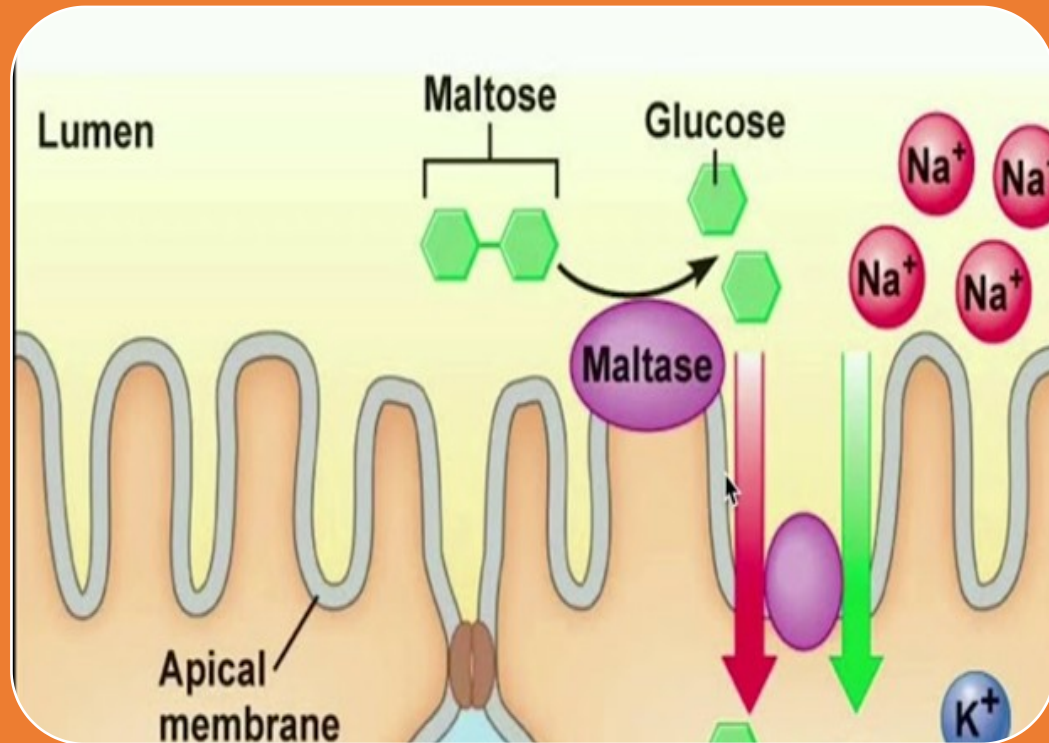
Lactose intolerance and sucrase-isomaltase deficiency



Protein digestion



Absorption of amino acids



Carbohydrates digestion

Clinical case scenario



A 6-year-old girl presents to her primary care physician with **abdominal pain, bloating, flatulence, and diarrhea** after **drinking milk**. She has a past history of similar symptoms after **eating any dairy product** (including **voqhurt and ice crème**). **What is the**



Dairy products

- The patient is diagnosed with **lactose intolerance**. The doctor prescribed her **lactase enzyme** tablets medications and the symptoms were improved.





Carbohydrates are classified according to products of hydrolysis into:

Carbohydrates

MONOSaccharides

1 sugar unit

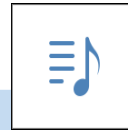
Glucose, Fructose, Pentose



No need for digestion

Disaccharides

2 sugar units



Lactose, Maltose, Sucrose



OLIGOSaccharides

(3-10) sugar units

POLYSaccharides

> 10 sugar units

GI &

Starch, Glycogen



Digestible

Cellulose is Not Digestible

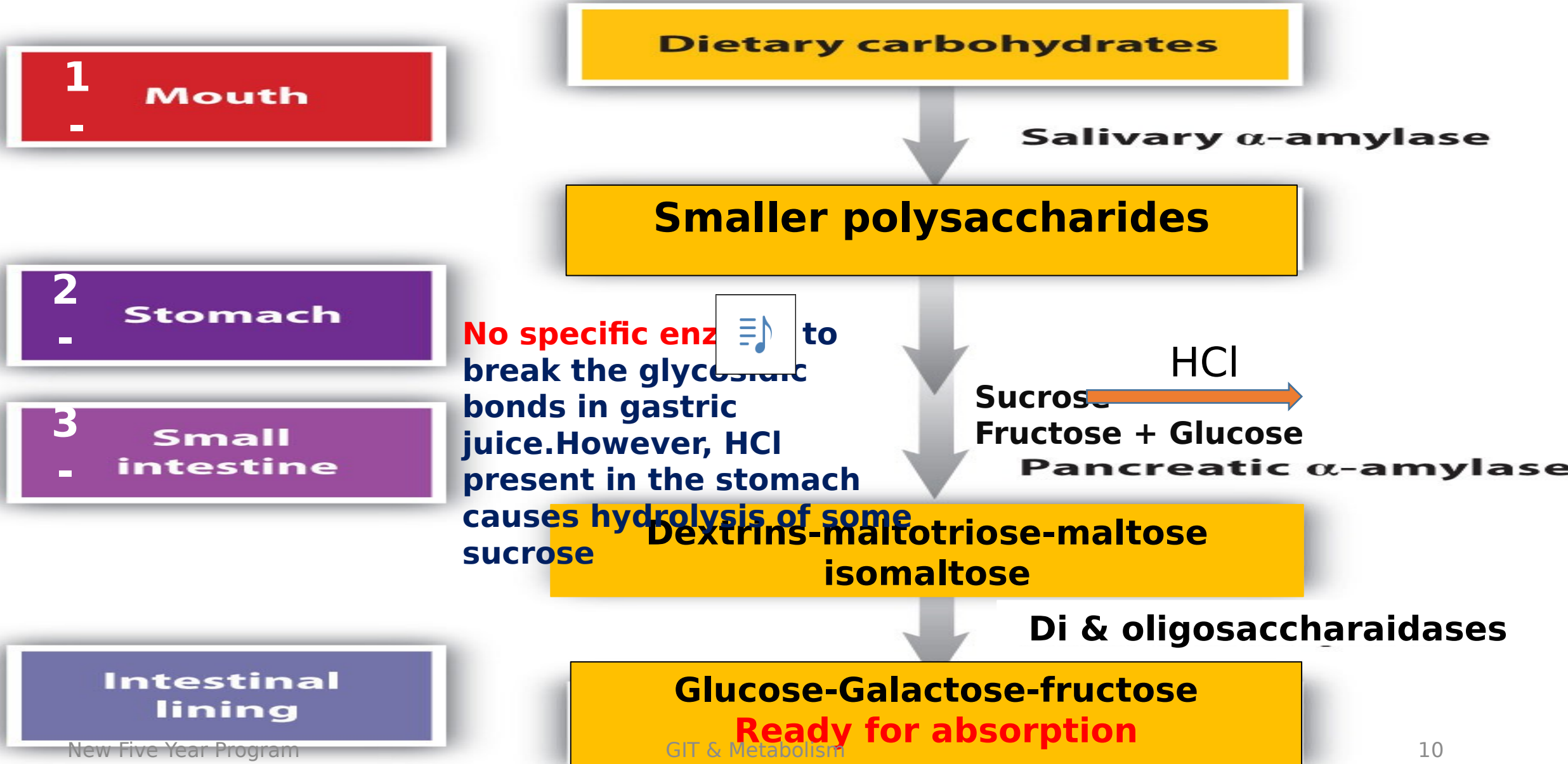
- **Cellulose**

- ***It is formed of glucose linked by β 1-4 glycosidic bonds. GIT enzymes don't act on the form of the bond.***
- ***It forms the bulk of stool & prevents constipation***



<https://www.newfoodmagazine.com/article/26512/cellulose-food-environmentallyfriendly/>

Stages of carbohydrates digestion





Amylases

Salivary amylase (ptylin)

Starts **in the mouth** during mastication

It hydrolyses **α -1 $\rightarrow$ 4 glycosidic** linkages of the polysaccharides (starch and glycogen).

It is requires **Cl⁻** ion for activation

Optimum pH of **6.7**. its action stops in the stomach when the pH falls to 3

short duration of food in mouth

Pancreatic amylase (amylopsin)

Starts when Food bolus meets the pancreatic juice **in the duodenum**

Optimum pH=**7.1**

Longer time of food in the

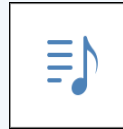
Pancreatic amylase



It is an **endoglucosidase** = **can not give free glucose**)

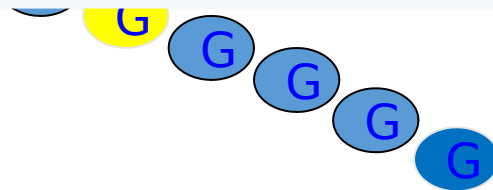
Starch/Glycogen

***Maltose/ Isomaltose/
Dextrins and
oligosaccharides***

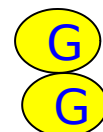


extrins

α 1-4 link



maltose

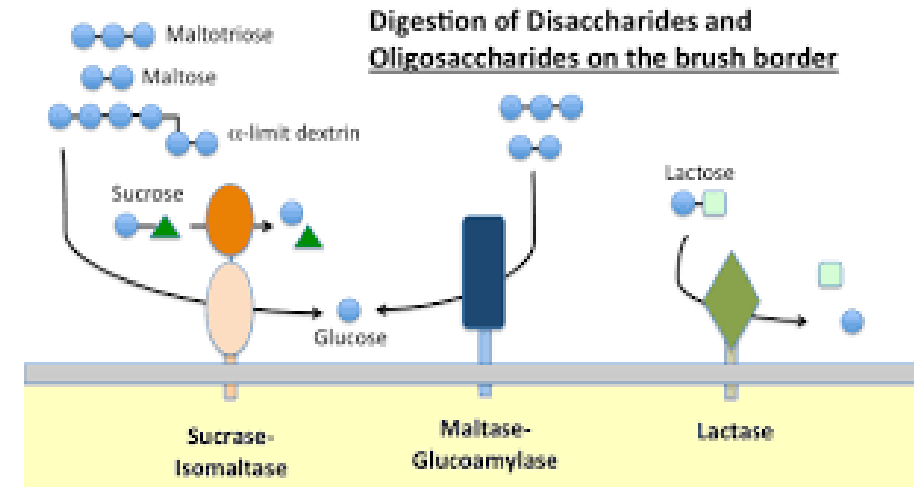


isomaltose

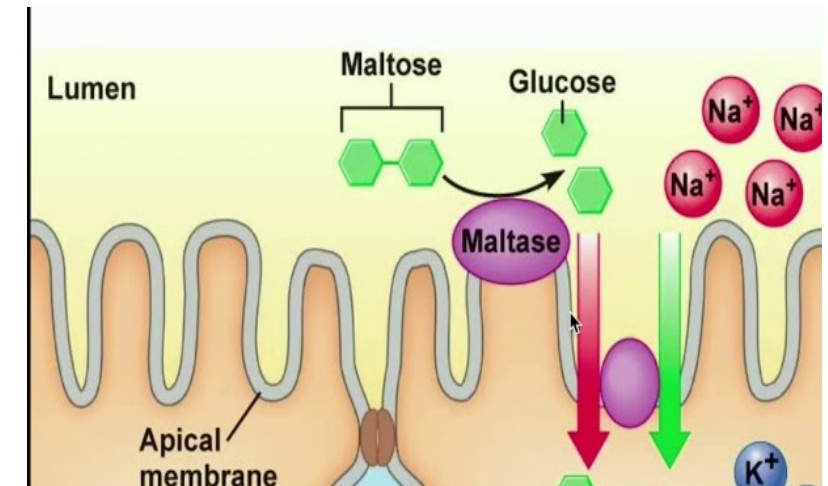
Disaccharidases



- They are synthesized by intestinal epithelial cells and present on the surface of brush border of these cells as integral membrane glycoproteins
- They act on the products of α amylase digestion of polysaccharides together with the ingested disaccharides
- They include: **Maltase, Isomaltase, Sucrase, Lactase.**



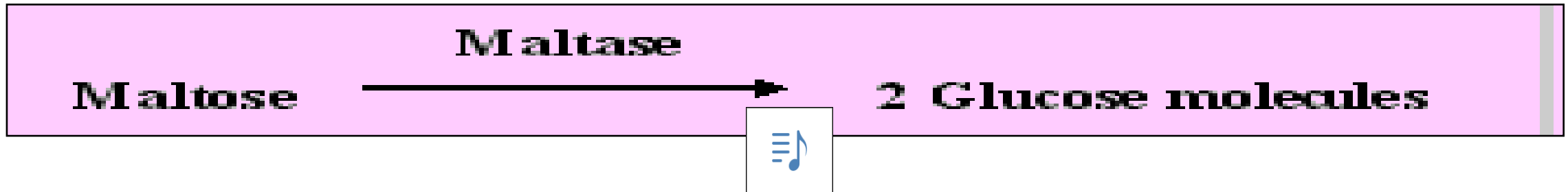
<http://www.vivo.colostate.edu/hbooks/pathphys/digestion/smallgut/benzymes.html>



<https://www.youtube.com/watch?v=dERCrrzNRL8>

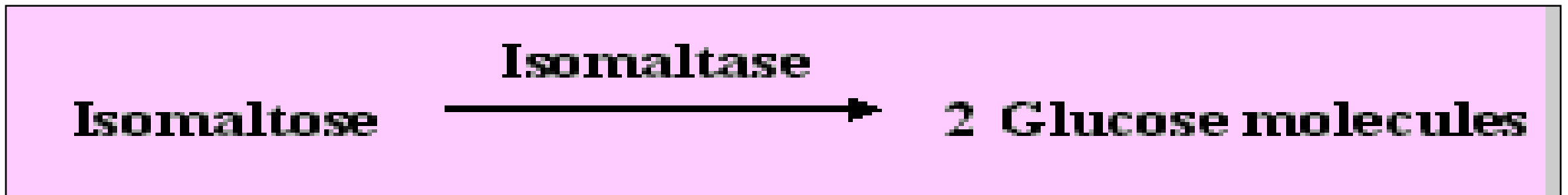
1. Exo α 1-4 glucosidase (maltase):

It can release the terminal glucose subunits linked in α 1-4 glycosidic linkages of dextrans or maltose.



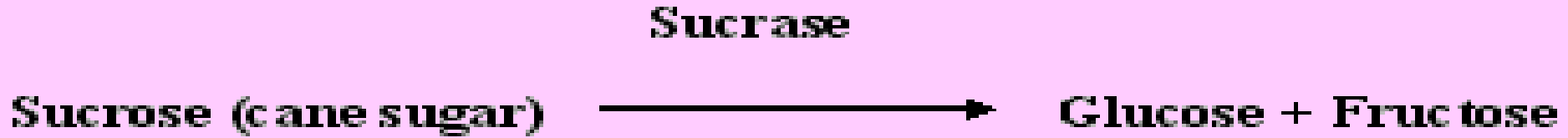
2. Isomaltase:

It can hydrolyze the α 1-6 glycosidic bond of isomaltose



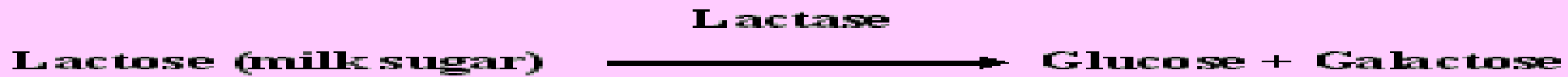
3. Sucrase:

It can hydrolyze the α 1-2 glycosidic bond of sucrose to release glucose and fructose.



4. Lactase:

It hydrolyses β -1,4-glycosidic linkage lactose to glucose and



So the end product of carbohydrate digestion

Glucose-Galactose-fructose
Ready for absorption



Lactose intolerance and sucrase-isomaltase deficiency

USMLE Quiz



. A 50-year-old female presents with severe abdominal pain. Her serum amylase and lipase levels are abnormally elevated and she is diagnosed with pancreatitis. Which linkage between glucose residues is cleaved by amylase ?

a) α -1,4

b) α -1,6

c) β -1,4

d) α 1,2

e) β -1,6



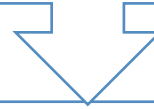
Lactose intolerance

- It is a condition resulting from Lactase deficiency.
- Lactase is responsible for breaking down lactose into glucose and galactose which are absorbed.
- The clinical symptoms of lactose intolerance follow **dairy product** (milk, yoghurt, ice creme) intake.

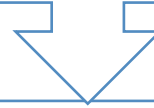


Biochemical basis of Lactose intolerance

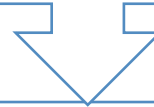
Absence of lactase in the brush border of the small intestine.



The osmotic effect of the undigested and unabsorbed lactose leads to an influx of fluid in the lumen of the small intestine



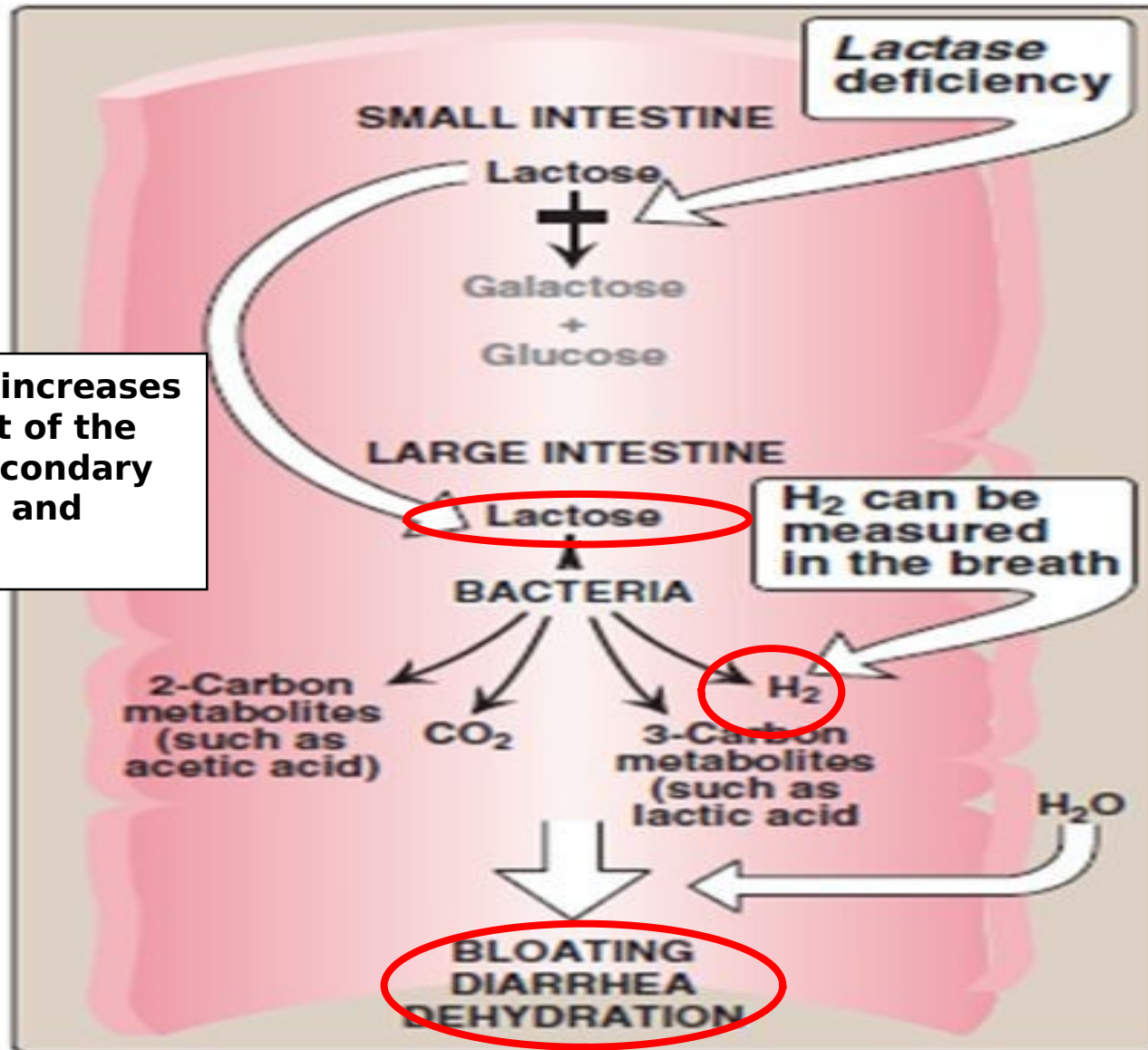
The increased retention of fluid results in the symptoms of diarrhea with its abdominal distention and cramping.



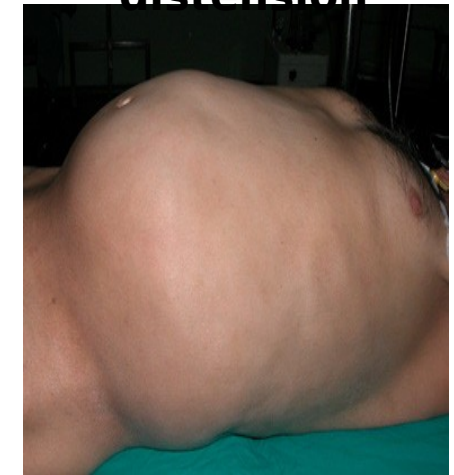
The bacteria in the colon ferment the lactose into a variety of gases, leading to increased flatulence

Explain on biochemical basis symptoms of Lactose intolerance

unabsorbed lactose increases the osmotic gradient of the luminal contents, secondary drag water in lumen and leads to **Diarrhea**



Abdominal distension



Flatulence



Types (Causes) of Lactose intolerance

- Lactase deficiency may be:

1-Congenital or primary;

Due to a **defect in the gene** producing the enzyme protein .

2-Acquired or secondary (adult hypolactasia):

- The most common type 
- Due to Damage of intestinal brush border intestinal enzymes due to :
 - **GIT surgery**
 - **Gastroenteritis** due to mucosal damage , and drugs like chemotherapy.
 - **Age-dependent:** loss of lactase activity and reduction in the amount of enzyme produced with the age.

Diagnosis of Lactose intolerance

- *The commonly used tests are : -*
- **Hydrogen Breath Test**
- **Stool Acidity Test**
- **Mucosal biopsy** confirms the diagnosis.



Treatment of lactose intolerance:

- 1. Intake milk-deficient in lactose as Soy milk**
- 2. Intake of yogurt** (Partly digested dairy products by bacteria → decrease lactose content)
- 3. Lactase enzyme** drops or tablets (**Yeast tablets**) prior to eating
- 4. Treat the cause in secondary type**
- 5. Getting enough calcium and vitamin**

Sucrase-Isomaltase deficiency

- These 2 enzymes are synthesized on a single polypeptide chain, hence , their deficiencies coexist.
- **Signs and symptoms**
- Same as that of lactose intolerance (but following Sucrose containing food e.g. sweets and fruit juice)
- History confirms the diagnosis.
- Most confirmatory test is mucosal biopsy.



<https://www.pinterest.co.uk/pin/401242648053224987/>



<https://www.myguthealthtoday.com/eight-facts-sucrose-intolerance/>

Milk intolerance result from the deficiency of the digestive enzyme:

☒ A. Lactase

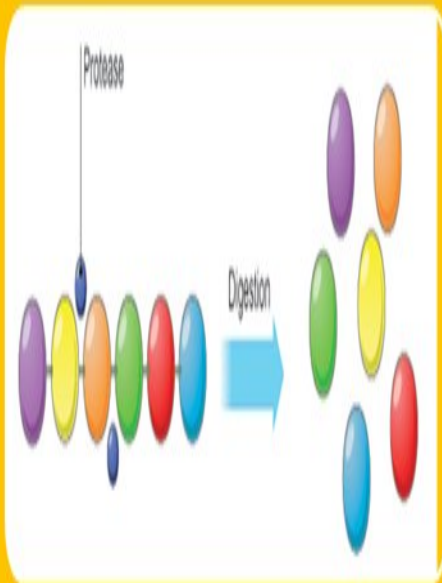
B. Lipase

C. Rennin

D. Trypsin

E. Amylase





Protein digestion

Digestion of proteins



Proteins are first  **digested** and hydrolyzed to amino acids

Amino acids (AA's) are then **absorbed**.

 A.A.'s in the  d are called **amino acid pool**



<https://www.slideshare.net/ashokktt/digestion-and-absorption-of-proteins-44933621>



Digestion of Proteins (Overview)

Mouth

No
enzymes

Stomach

Pepsin
Renin

Pancreas

Trypsin
Chymotrypsin
Elastase
Carboxypeptidase A
Carboxypeptidase B

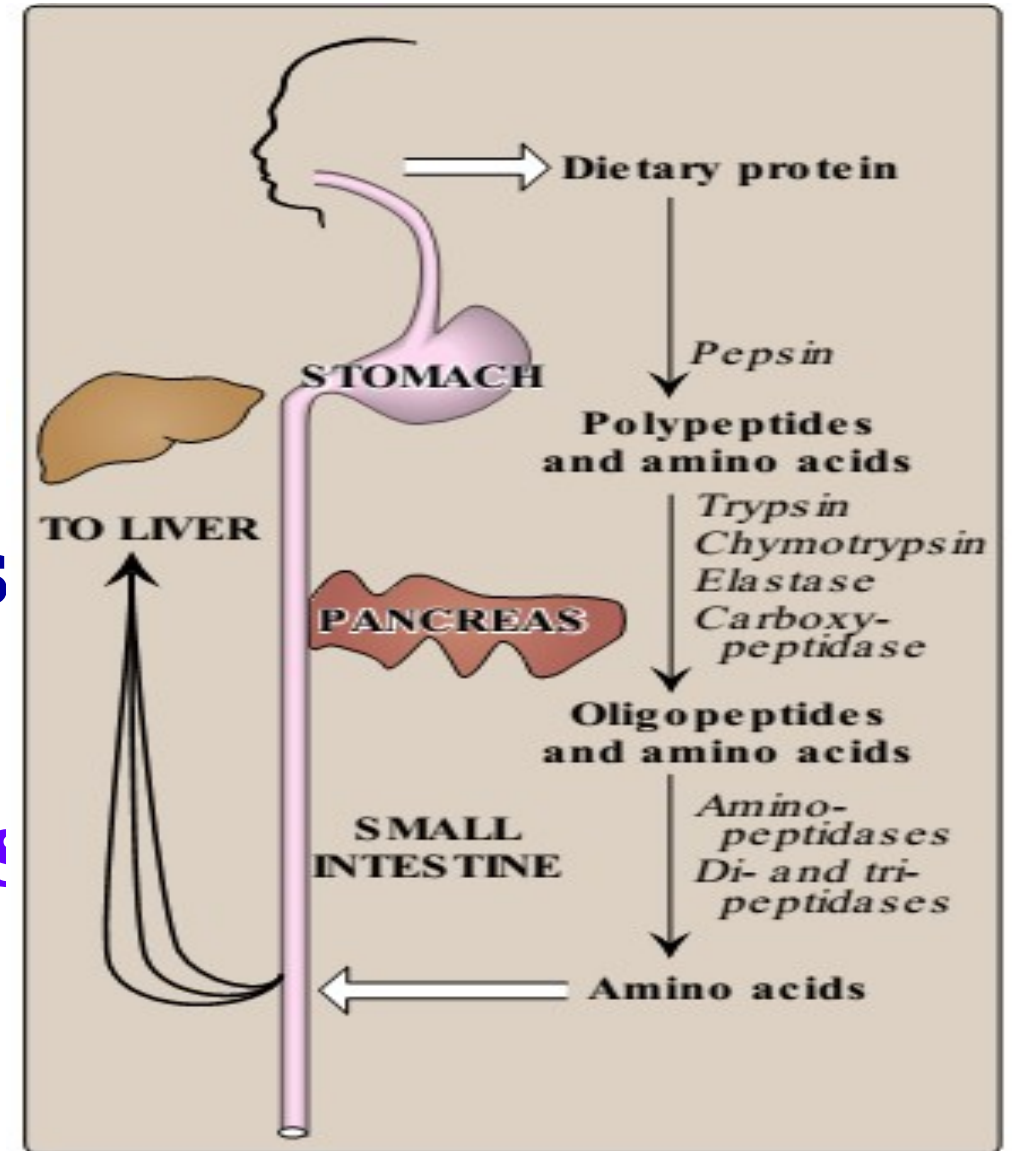
Intestine

Aminopeptidase
Dipeptidase

Phases of proteins Digestion



1. Gastric phase
2. Pancreatic phase
3. Intestinal phase



Digestion of dietary proteins by the proteolytic enzymes of the gastrointestinal tract

hydrolyses the peptide bond adjacent to acidic or aromatic amino acids.	endopeptidase	Pepsin	Gastric -1 phase
hydrolyses the peptide bonds containing the carboxylic group of basic amino acids (arginine)	endopeptidase	Trypsin	-2 Pancreatic phase
attacks the peptide bonds formed by carboxylic group of aromatic amino acids, e.g. (phenylalanine)	endopeptidase	Chymotrypsin	
hydrolyzes the peptide bonds next to some non-polar amino acids such as (glycine & alanine)	endopeptidase	Elastase	
It acts on the C-terminal peptide bond. 	Exopeptidase	Carboxypeptidase	
separating the N - terminal amino acids in oligopeptides	Exopeptidases	Amino-peptidases	-3 Intestinal phase
act on tri- & dipeptides producing free amino acids		Tri-peptidases & Di-peptidases	



https://www.liverpool.ac.uk/~agmcclen/Medpracs/practical_3/theory_3.html

: Gastrin stimulates release of
HCL from parietal cells

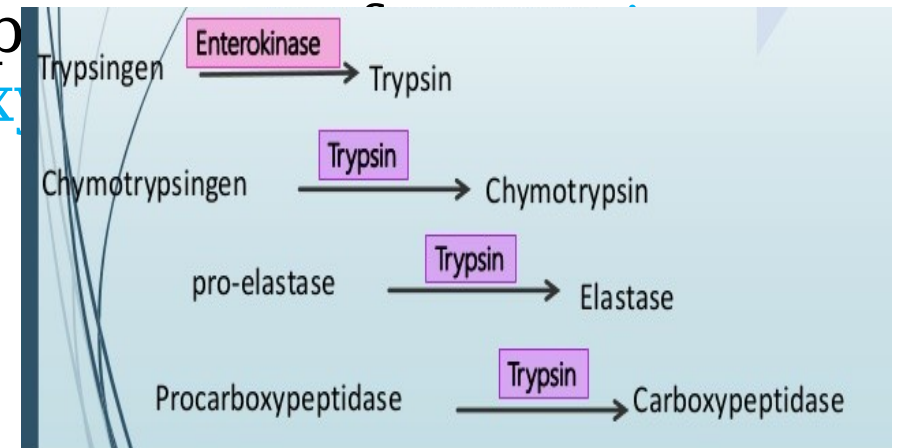
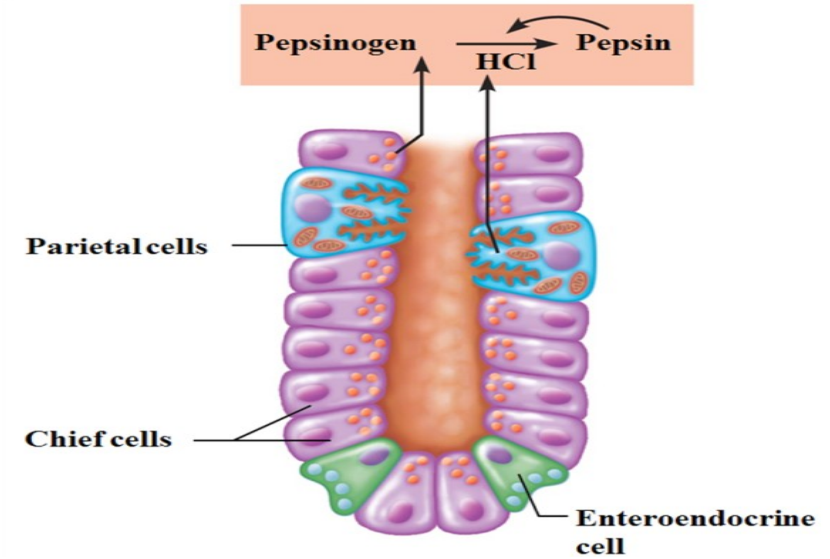
Pepsin from chief cells

proteins $\xrightarrow{\text{Pepsin} + \text{HCL}}$
+ a.a.s

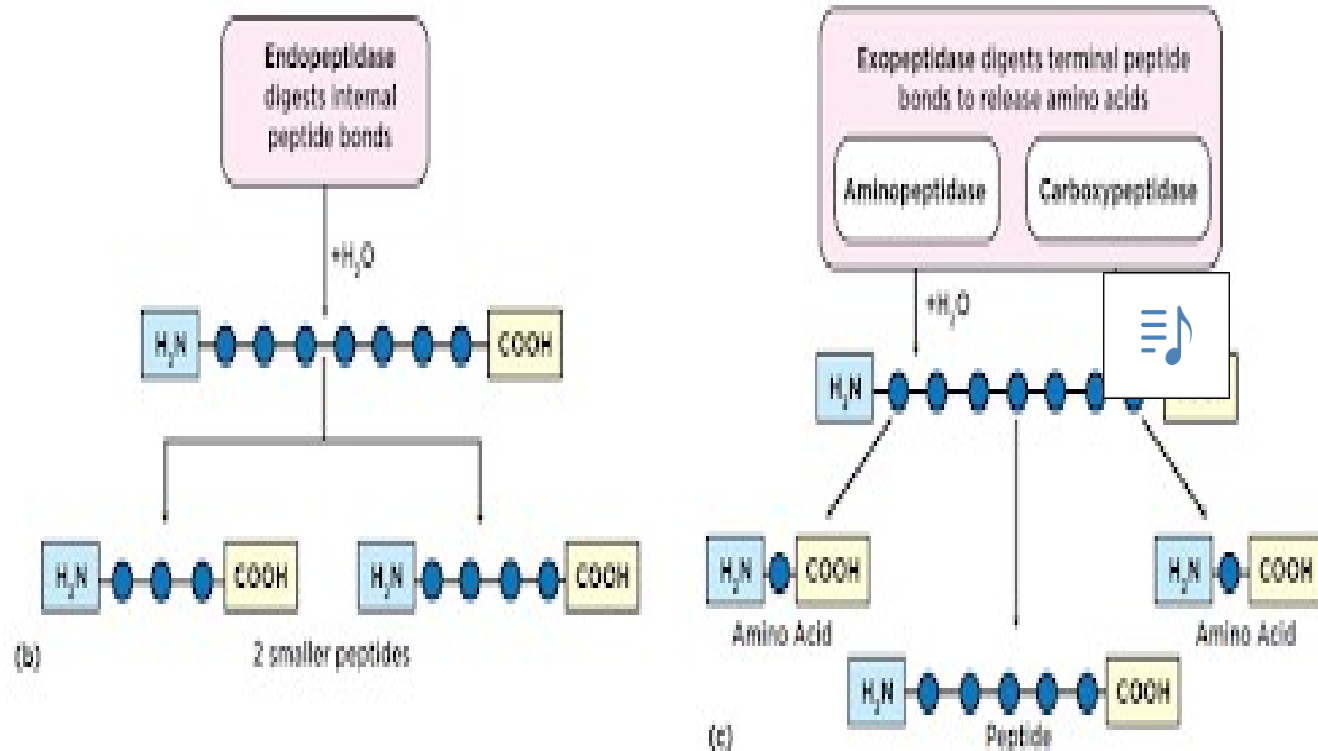
smaller polypeptides

Most of these proteolytic enzymes are secreted
as zymogens (Pepsinogen, trypsinogen, chymotrypsinogen,
proelastase, and procarboxypeptidase are p
trypsin, chymotrypsin, elastase, and carboxy
respectively)

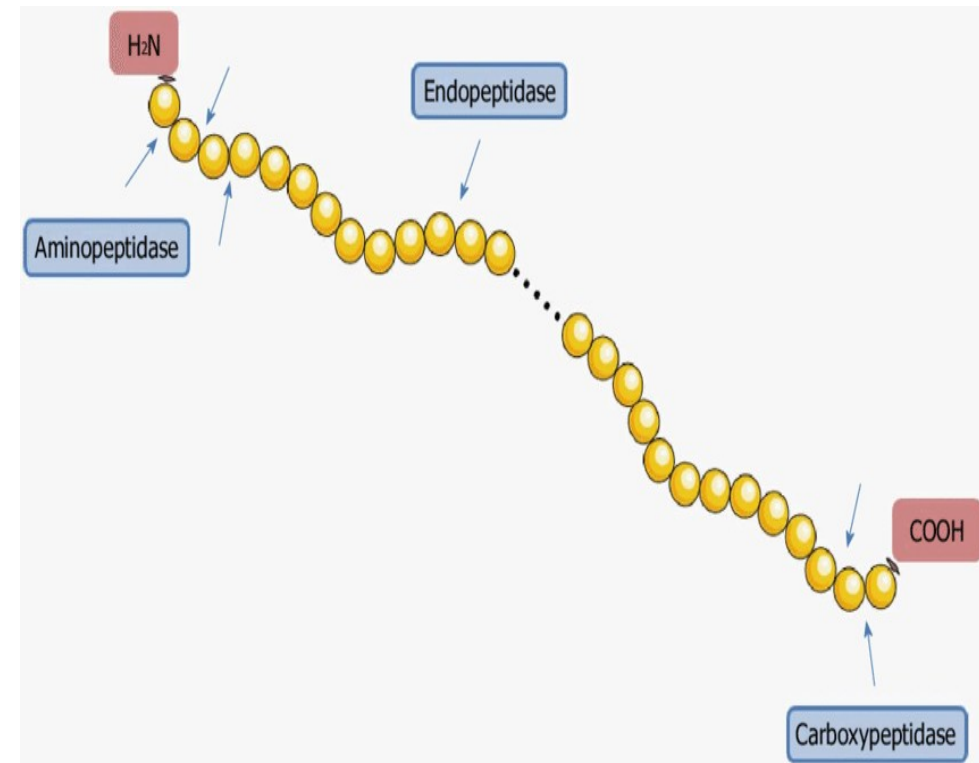
<https://www.slideshare.net/ashokktt/digestion-and-absorption-of-proteins-44933621>



Endopeptidase vs exopeptidase



https://www.google.com/url?sa=i&url=https%3A%2F%2Fwww.deerland.com%2Fglutalytic%2Fgluten-digestion%2F&psig=AOvVaw005jv-WHpGON3Vi57_AdTS&ust=1597330797347000&source=images&cd=vfe&ved=0CAIQjRxqFwoTCliz3_71lesCFQAAAAAdAAAAABAD

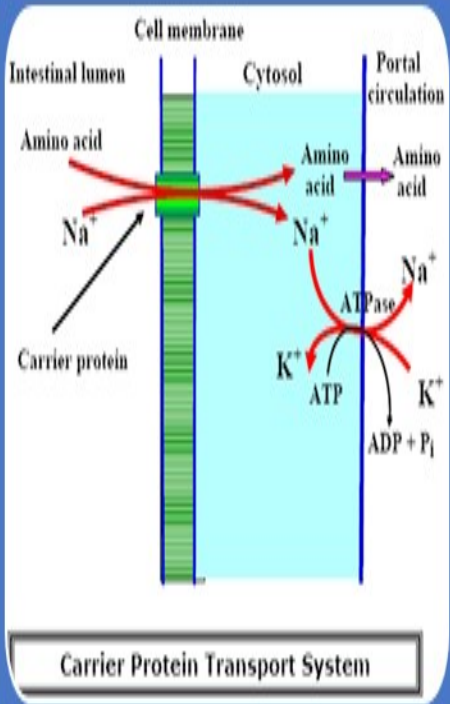


https://www.google.com/url?sa=i&url=https%3A%2F%2Fwww.researchgate.net%2Ffigure%2FSimplified-representation-of-the-concept-of-endo-and-exopeptidases-Endopeptidases-cleave_fig1_311750351&psig=AOvVaw005jv-WHpGON3Vi57_AdTS&ust=1597330797347000&source=images&cd=vfe&ved=0CAIQjRxqFwoTCliz3_71lesCFQAAAAAdAAABAj

From the pentapeptide,
phe-ala-lys-arg-leu,
Arginine residue is split off by:

- a. Trypsin
- b. Chymotrypsin
- c. Aminopeptidase
- d. Carboxypeptidase



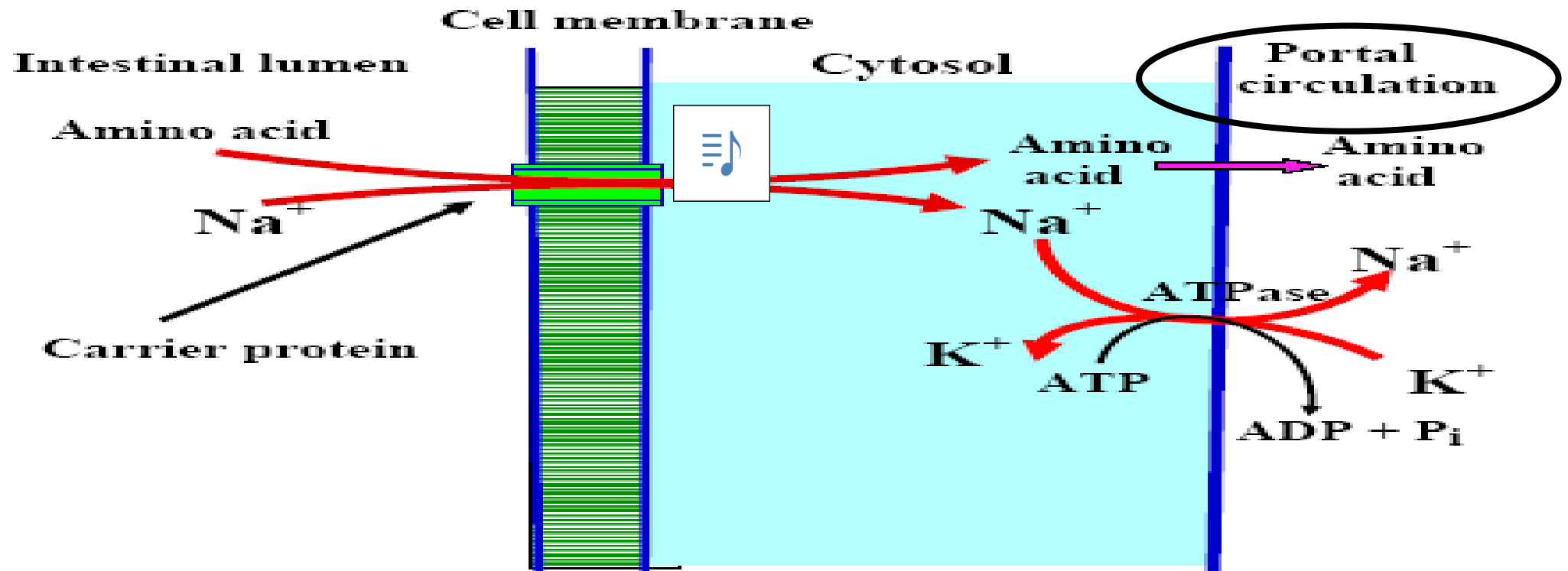


Absorption of amino acids

Absorption of amino acids

Active transport

a protein carrier mediated - system requiring **ATP** obtained from **Na / K - ATPase**.



Key Points



- Dietary carbohydrates can be digested mainly by amylases and disaccharidases with minimal contribution of the stomach.
- Many fibers are not digestible. However, they should be obtained in diet.
- Adult hypolactasia is common amongst most of the world's population.
- Digestion of proteins starts in the stomach with completion by pancreatic and intestinal phases.
- Most of the proteolytic enzymes are secreted as zymogens (inactive precursors).
- Absorption of amino acids occurs by means of active transport.

SUGGESTED TEXTBOOKS



- "Lippincott's Illustrated Reviews in Biochemistry" by P.C.Champe, R.A.Harvey and D.R.Ferrier
- "Harper's Biochemistry" by R.K.Murray, D.K.Granner, P.A. Mayes and V.W.Rodwell.
- Fundamentals of Clinical Chemistry (Tietz) Sixth
- "Textbook of Biochemistry with Clinical Correlations" by T.M.Devlin
- **www.namrata.co- *Biochemistry for medics***

Thank you